DOCUMENT RESUME

ED 237 066 IR 010 893

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TITLE Computer Programming by Kindergarten Children Using LOGO.
PUB DATE 21 Jun 83
NOTE 17p.; Paper presented at the Association for Media and Technology in Education in Canada/ADATE Confluence '83 (Montreal, Canada, June 21, 1983).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Cognitive Processes; *Computer Literacy; Computer Programs; *Conservation (Concept); Geometric Concepts; *Kindergarten Children; Primary Education; *Programing; *Psychomotor Skills; *Spatial Ability
IDENTIFIERS *LOGO Programing Language

ABSTRACT

Conservation ability, spatial motor ability, age, and gender were used as predictive variables in a study of 26 kindergarten children's computer programming ability. A preliminary pilot study with first graders had suggested that programming success was related to the ability to reverse thought processes. In both studies, children were taught to program with the LOGO Turtle using a simplified form of LOGO. The subjects were 12 girls and 14 boys from a kindergarten class of a private school emphasizing creativity. Scores from a school-administered conservation test and from the geometric design subtest of the Weschler Preschool and Primary Scale of Intelligence were used. Students were given a 30-minute computer literacy demonstration and two 20-minute sessions of unstructured exploration with the four LOGO commands for the procedures. Individual posttesting required the child to draw geometric shapes with the Turtle. Results indicated that conservation ability was a good predictor of programming skill although the four variables together did not account for a significant amount of variance in programming ability. A replication of the study with 16 kindergarten children in a French-immersion public school showed that none of the predictors was significant. Six references are listed. (LMM)

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ED237066

Computer Programming by Kindergarten Children Using LOGO

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May 1983

Paper presented at AMTEC/ADATE Confluence '83, Montreal, June 21, 1983.

IR010893

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ABSTRACT

Twenty-six Kindergarten children participated in a project in which they were taught to program with the Turtle using a simplified form of LOGO. They were tested to ascertain their conservation ability and their spatial-motor ability. Their scores, along with their ages and gender, were used as variables to predict their ability in computer programming. Although a multiple regression analysis established that these four predictors together did not account for a significant amount of variance in programming ability, a simple regression analysis indicated that conservation skill was a good predictor of programming ability.

A replication of the study with another class of sixteen kindergarten children yielded results that at first seemed quite dissimilar and raised some interesting questions.

With the widespread introduction of microcomputers into elementary schools, there is a need to examine the ways in which they can most effectively be used, especially with young children just beginning their school experiences.

There is evidence that children as young as three years of age can use interactive programs that are designed for their developmental level. Piestrup (1981) describes a successful field test in a nursery school in which colour graphics, music and digitized voice were used with a standard keyboard to teach preschoolers the concepts of above and below and left and right. According to Martin (1981), preschoolers exhibit deep concentration and express varying moods while interacting with computers. Swigger and Campbell (1981) assert that young children can and will use computers, and call for study into what activities, with what techniques and with what effect.

We therefore know that the computer can program the child, which leads us to question the inverse: can the young child program the computer? Programming can be defined as a series of instructions to a computer in order to have it carry out a task. Papert (1980) defines it as "nothing more or less

than communicating to (the computer) in a language that it and the human user can both 'understand'."

Papert promotes the view that very young children can program the computer using the Turtle graphics capability of LOGO, an interactive, recursive procedural language designed specifically for self-managed learning. He describes this process of programming the computer in terms of Piaget's theory of genetic epistemology, in which the learner is an adaptive system, interacting with its environment in a process of assimilation and accommodation. The learner is therefore seen as a problem solver; but how effective is the young child as a problem solver in programming the computer?

The difficulty for a preoperational child in generating problem solving strategies is that she cannot reverse the direction of her thought (Almy, 1966). Therefore a solution to a problem comes out all right or all wrong. If a solution is wrong, the child will attempt a different approach for which prior attempts have little bearing, an unrelated trial-and-error strategy.

As the transition to the stage of concrete operations occurs (approximately five to seven years of age for North American children), a child can begin to apply the principle of reversibility to a problem, hence developing a strategy for

working backward to where she went wrong in order to correct and then proceed. This principle of reversibility is the basis of the most common strategies for "de-bugging" in computer programming.

A pilot study to examine children's attempts at computer programming was carried out over a period of three months, with subjects just beginning Grade One. A modified LOGO for non-readers (Abelson, 1982) was used in which the need for keyboard facility is minimized. This study ascertained that these Grade One children were able to program, not only to solve problems set for them, i.e. to draw a square, a rectangle and a triangle, but also to solve more complex problems that they set for themselves, eg. combinations of the previously-mentioned geometric shapes, and circles. The evidence strongly indicated that their success in these programming tasks related to their ability to reverse their thought processes.

As well as cognitive developmental level, another key factor which could influence a young child's ability to program effectively is her spatial-motor ability. Since the central focus of Turtle graphics is plane geometry, it is necessary for a child to be familiar with and to be able to draw the basic geometric shapes. The children in the study were all familiar with the shapes, and most were able to draw them with ease and

accuracy.

Although chronological age on a broad scale is self-evident in the ability to program, the differences in age within the class ranged over twelve months only. Nonetheless it appeared within this range that the younger children were the ones with greater difficulty in attending to, as well as carrying out, the prescribed tasks.

A popular view of computers and programming holds the belief that these skills lie in the masculine domain and that women tend to have little interest or ability in this area. The pilot study showed little difference overall in enthusiasm or ability for either boys or girls, although some of the girls approached the computer initially with timidity and anxiety.

On the basis of the evidence from the pilot study it was decided to survey a younger group of children, the Kindergarten class in the same school, to ascertain their programming ability, with the four above-mentioned factors, cognitive ability, spatial-motor ability, age and sex, considered as predictors of programming capability.

METHOD

Subjects

The 26 subjects, 12 girls and 14 boys, came from the kindergarten class of a private school emphasizing creativity. Their mean age at the time of the study was 72.5 months, with a range from 67 to 78 months.

Materials

An Apple II+ computer system was used for the study. The geometric design subtest of the Weschler Preschool and Primary Scale of Intelligence was used to test spatial-motor ability.

Procedure

The conservation test had been administered in the school earlier and the data were made available for this study.

The geometric design test was administered according to the WPPSI manual and scored accordingly.

Once these tests had been administered over a period of a week, the group was then given a thirty-minute computer literacy demonstration, with some hands-on experience for the children; this included an introduction to the four single-letter commands needed to make the Turtle draw the shapes on the computer screen. Over the next two weeks the subjects, in pairs, were brought to the computer for two twenty-minute sessions of unstructured exploration with the four commands on the computer. No instruction was given other than a review of the commands if necessary. At the end of this period the subjects were tested individually.

For the testing, a review of the commands was given and the subject was asked to teach Turtle to draw a square. If the task was completed within five attempts or five minutes, whichever came first, the subject was then asked to teach Turtle to draw a rectangle. If the task was not accomplished successfully within the prescribed limits, the assumption was made that the subject would not be able to do the increasingly more difficult second, third and fourth tasks and the testing session was terminated, allowing a few minutes of free play with the Turtle so that the child did not perceive the session as negative. The procedure was the same for the second task (a

rectangle), the third task (a triangle) and the fourth (a circle). These geometric shapes were selected for the test because most children are very familiar with them and they also demonstrate the children's ability to manipulate the Turtle. The tasks were scored as follows:

+5	to attempt the figure
+20	to achieve the figure perfectly
+10	for a partial success with closure
-1	for each error

for a possibility of 100 for a perfect score.

RESULTS

All the variables for the regression analysis were continuous, excepting sex which was dummy coded.

In the initial regression analysis the obtained F of 2.62 was not significant at the .05 level and the null hypothesis could not be rejected. The only predictor variable with a significantly large beta (.89) was the conservation

score.

A stepwise regression analysis was then conducted which revealed that once more the conservation score was the only predictor with a beta weight significant at the .05 level. The predictor variable of age was excluded entirely, and although the F statistic for the three-predictor equation was significant at the .05 level, sex and geometric design scores were did not have significant beta weights.

Finally a simple regression analysis indicated that there was a linear relationship between the conservation test score and the computer test score. The conservation score accounted for 19% of the variance in the computer score, yielding an F of 6.77 which was significant at the .01 level. That is to say that the computer test score is related to the conservation test score.

DISCUSSION

The findings revealed that age, gender and spatial-motor ability did not account for significant variance in ability to program the computer in this particular group of kindergarten children. The only variable which accounted for a

significant amount of variance was conserving ability. Nonetheless, there still exists a large amount of variance not accounted for by this simple regression equation, which raises the question of other variables which have not been taken into account. Since the computer programming tasks were problem solving tasks, a more detailed examination of the literature on the problem solving skills of preschool children may suggest other variables which need to be examined.

That these subjects came from a rather specific subgroup of the kindergarten population suggests that it may be necessary to examine these factors with a more representative group. The small size of the sample also suggests further study with a larger number of subjects.

This exploratory study has provided some insight into the computer programming capabilities of young children in relation to their cognitive developmental level. It is recommended that this survey be undertaken with the addition of other factors involved in young children's problem solving skills and with a larger number of subjects drawn from the public school kindergarten population.

POSTSCRIPT

An opportunity to replicate the study in a French-immersion public school came up shortly after the study was completed. The same procedures were used with these Kindergarten children and the data was analysed.

The results in this study were quite different. No significance whatsoever was obtained through multiple regression analysis; none of the predictors offered a significant explanation of the variance of the response variable. An examination of the means and standard deviations (see table) raises some interesting questions, and a few hypotheses are offered for speculation.

The mean and standard devation for the ages of the two groups are quite similar. The scores for the geometric design test are very close as well.

There seems to be a large discrepancy between the two groups in their conservation scores: the private school children scored considerably higher, with most subjects well into the transition between the preoperational and the stage of concrete operations. For the most part, the public school

children appeared to be non-conservers. Given that the child's verbal responses are the criterion for assessing conserving ability, it may be that the public school children, whose "language of work" is French, could not perform as well in English in the test setting. This conjecture is supported by their performance in the computer programming test, where their problem solving strategies indicated a clear understanding of the principle of reversibility and an ability to apply it. This serves to confirm the correlation between conserving ability and computer programming ability, and again raises the question about what else predicts programming ability. It also raises another interesting question: Is it possible that the computer offers a more effective means to assess some aspects of cognitive development than more traditional instruments?

In the computer programming test, the public school children scored considerably higher than their private school counterparts. The one factor that offers some explanation for their outstanding performance has to do with making experiences concrete for young children. In introducing Turtle graphics to young children, it is recommended that the children should be encouraged to "play Turtle", i.e. to pretend that they are the Turtle and that the floor is the screen. This gives them the opportunity to walk through the moves that they want the Turtle to make, an excellent problem solving strategy. Both groups were taught to "play Turtle" but the public school group

spontaneously used this strategy time and again, especially during the test sessions, and with great success; whereas the private school group used it rarely, for two reasons: lack of space in the computer area, and an apparent lack of interest in that aspect of their computer experience.

This study has only just been completed, which means that there has not been time to completely analyze the results. The intention is to run T-tests on the results, and possibly to combine them for analysis.

Table 1

Means (and standard deviations) for the two kindergarten groups

SCHOOL	AGE IN MONTHS	CONSERVATION SCORE	GEOMETRIC DESIGN SCORE	COMPUTER PROGRAMMING SCORE
Private	72.50 (3.50)	18.50 (7.76)	13.81 (3.69)	53.04 (15.66)
Public	73.00 (3.50)	12.44 (8.48)	13.38 (4.05)	75.94 (20.35)
Note. Maximum score		36	26	100

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